Military-Related R&D:
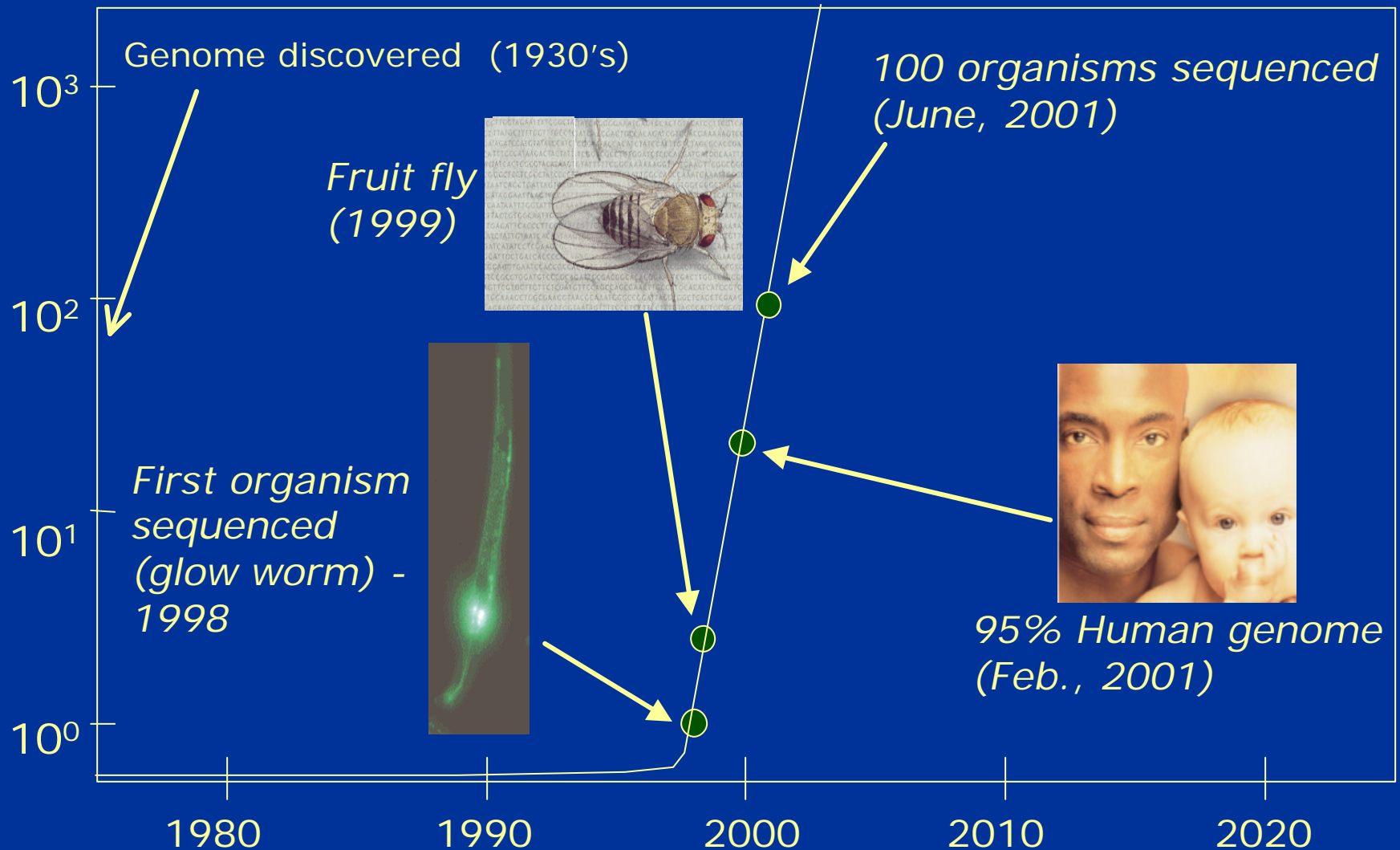# An Academic's View

Peter Lee
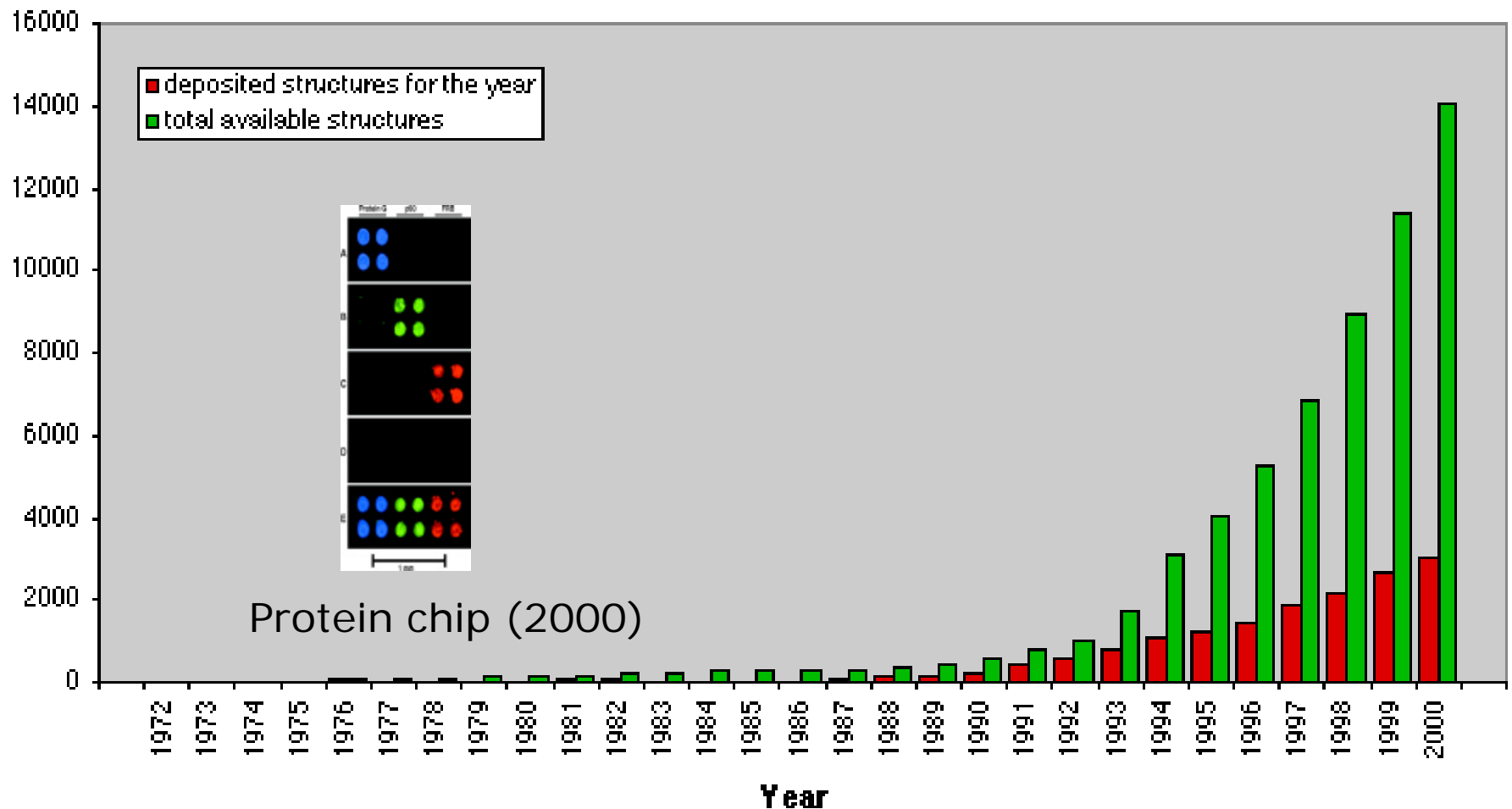
Carnegie Mellon University

S&T "Megatrends"
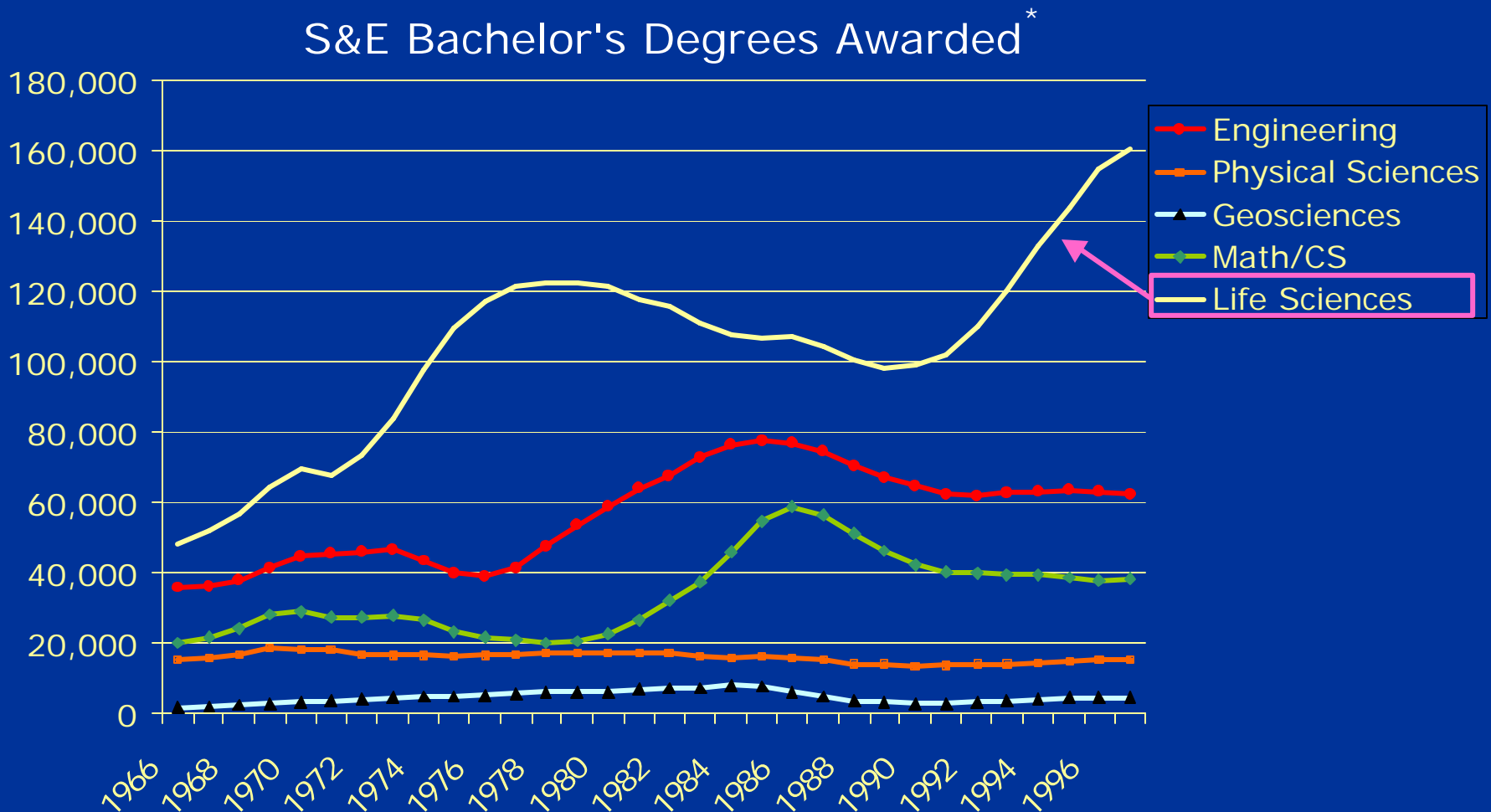
The age of the life sciences

Genome discovered (1930's)

Fruit fly (1999)

100 organisms sequenced (June, 2001)

First organism sequenced (glow worm) - 1998

95% Human genome (Feb., 2001)

1980   1990   2000   2010   2020

10^3
10^2
10^1
10^0

From Genomics to Proteomics

Protein chip (2000)

The nation's S&T talent pool

S&E Bachelor's Degrees Awarded[*]

Legend:
- Engineering
- Physical Sciences
- Geosciences
- Math/CS
- Life Sciences

Y-axis: 0, 20,000, 40,000, 60,000, 80,000, 100,000, 120,000, 140,000, 160,000, 180,000

X-axis: 1966, 1968, 1970, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, 1990, 1992, 1994, 1996

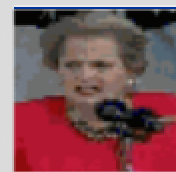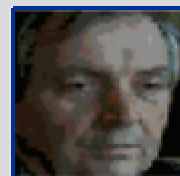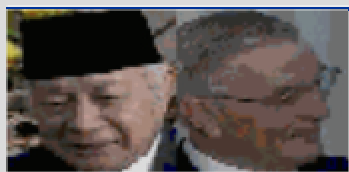[*] Source: The Higher Education General Information Survey (HEGIS) and the Integrated Postsecondary Education Data System (IPEDS). 4327 institutions in total were surveyed.

The rise of intelligent systems
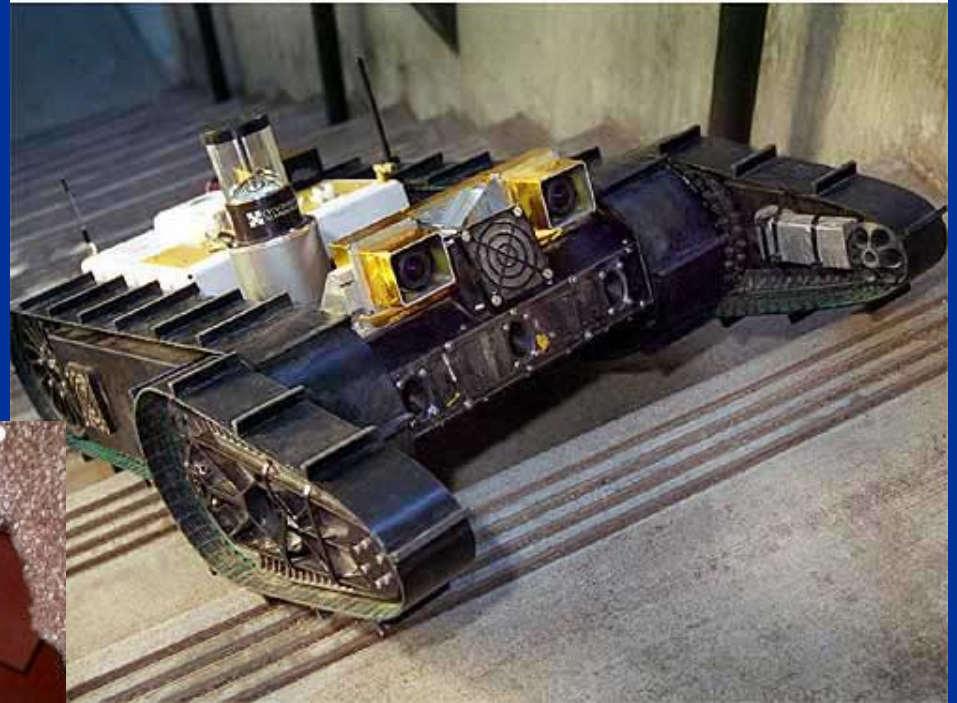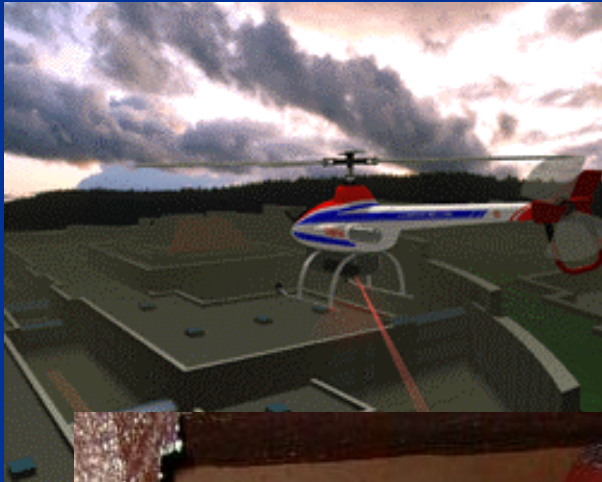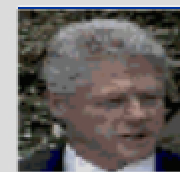
March 1998   April 1998   May 1998

Suharto economic reform meetings

U.S. policy on Indonesia

Habibie new president

El Niño wildfires

Student protests against Suharto

Video   **Transcript**

... said President Clinton Al Gore presented his policies... Gore stated.... In a gala affair, Clinton addressed....

Face Extraction

Name Extraction

Face/Name Association (Co-occurrence evaluation) → *Clinton*

Who is Gore?

Human Population 1900 2.5 Billion

Bob Franken Washington

REV. JESSE JACKSON NAT'L RAINBOW COALITION

Northern White Rhino 1980 1,000 1989 80

Courtesy NBC

Tim Russert NBC News

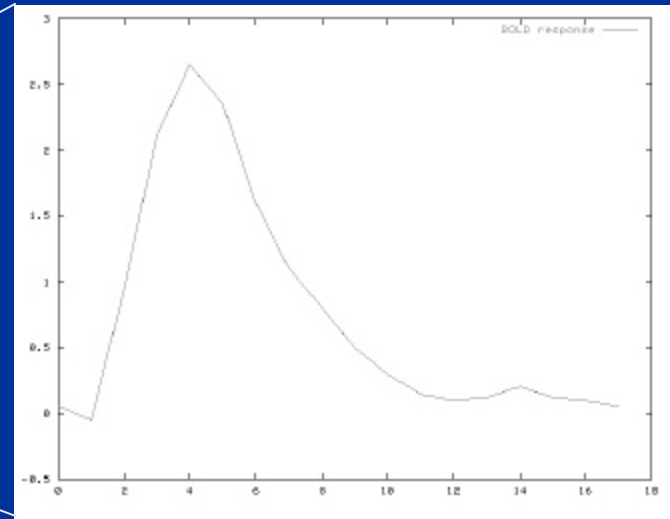Mountain Gorillas in Existence 400

THE WORLD TODAY

Washington CNN CNN Center

fMRI

MR signal at every point in a 3D grid covering the brain
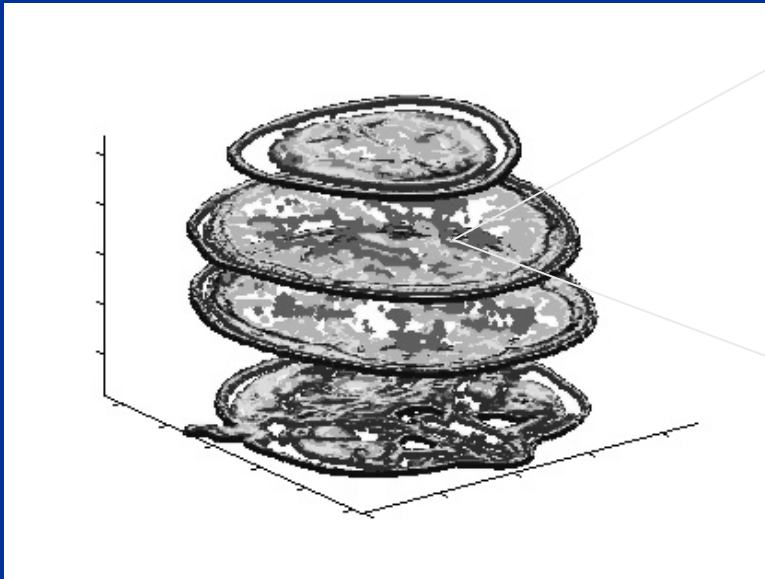
A few seconds of signal
(sampled at 1Hz)

voxel

- Grid of 64x64x7 *voxels*, each with a volume of ~3x3x5mm

- A voxel contains $O(10^5)$ neurons

- Typical sampling rates are 0.5Hz – 2Hz

- Signal reflects neural activity

Men and women, listening

"Men listen with only one side of their brains, while women use both"

Posterior

Anterior

M

F

0 10 46.7

Color indicates areas active during listening

← Men listening

←Women listening

(IU School of Medicine Department of Radiology)
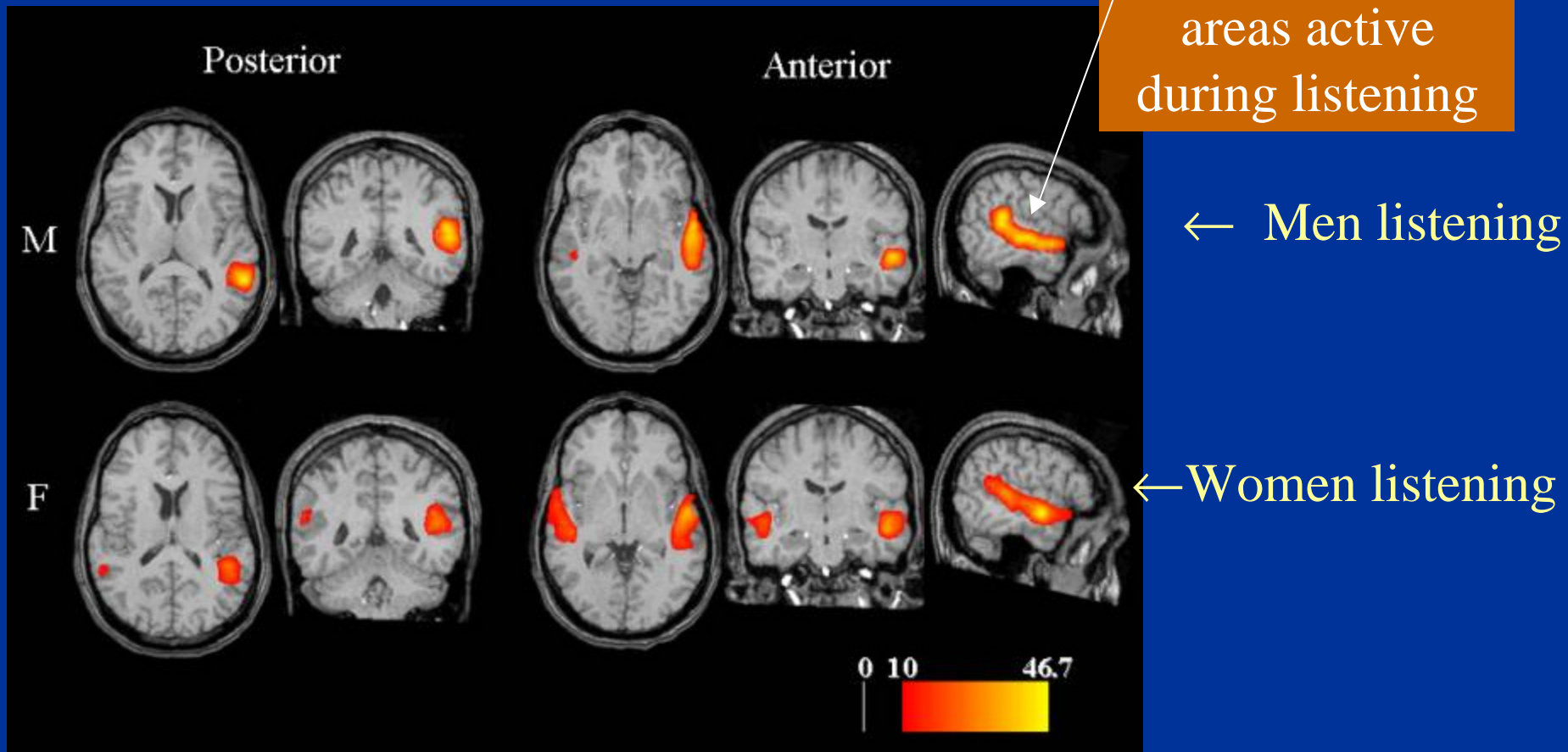
Functional brain imaging growth
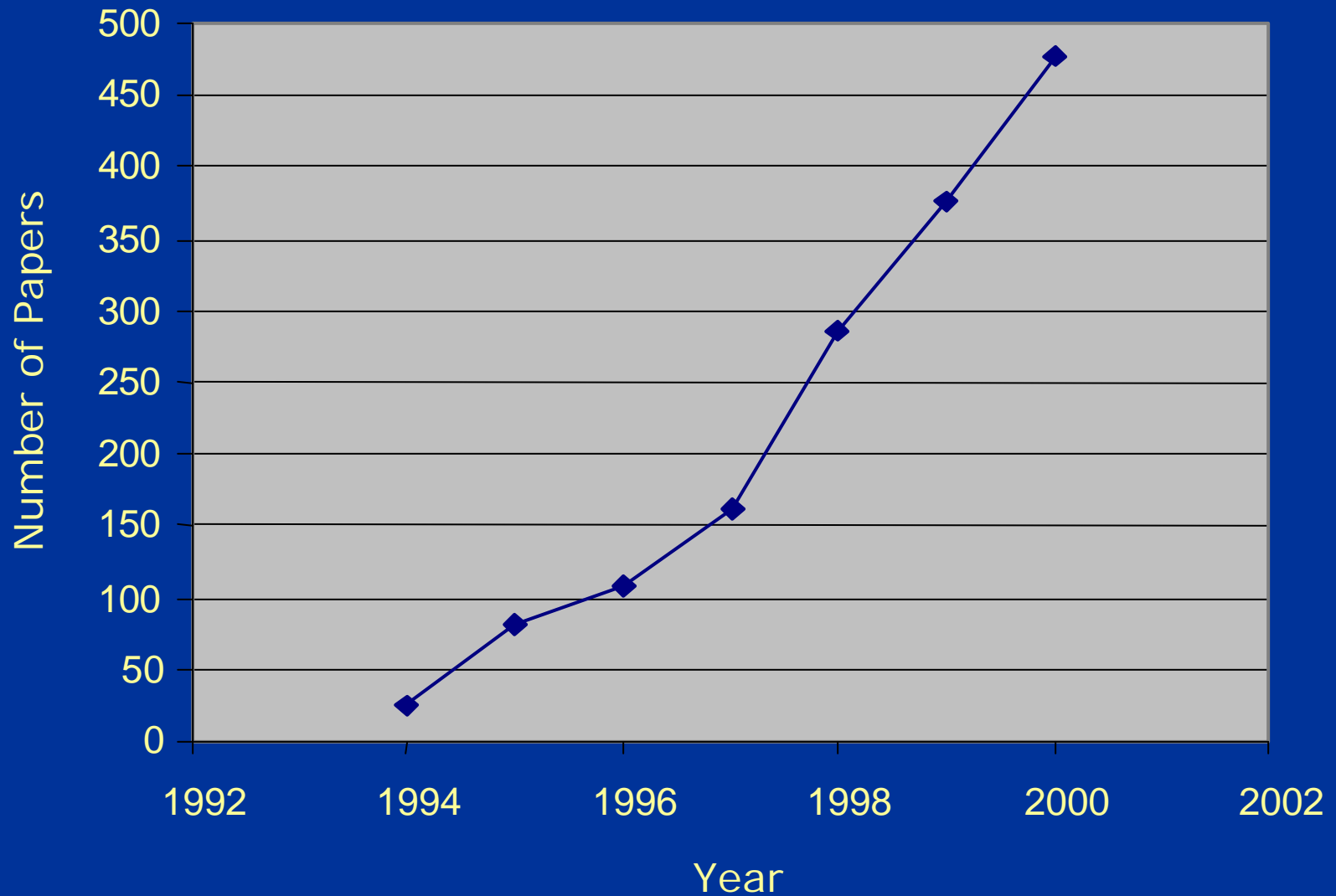
Nanotechnology becomes real

Design and manufacture at molecular scale is now possible in the laboratory

- 16 bit molecular memory at 10x density of silicon CMOS demonstrated

- n-p-n nanowire transistor with >16x gain demonstrated

- Resonant tunneling diode with a low temperature on-off ratio >1000 demonstrated

Operating nanotube memory

The digital communications era
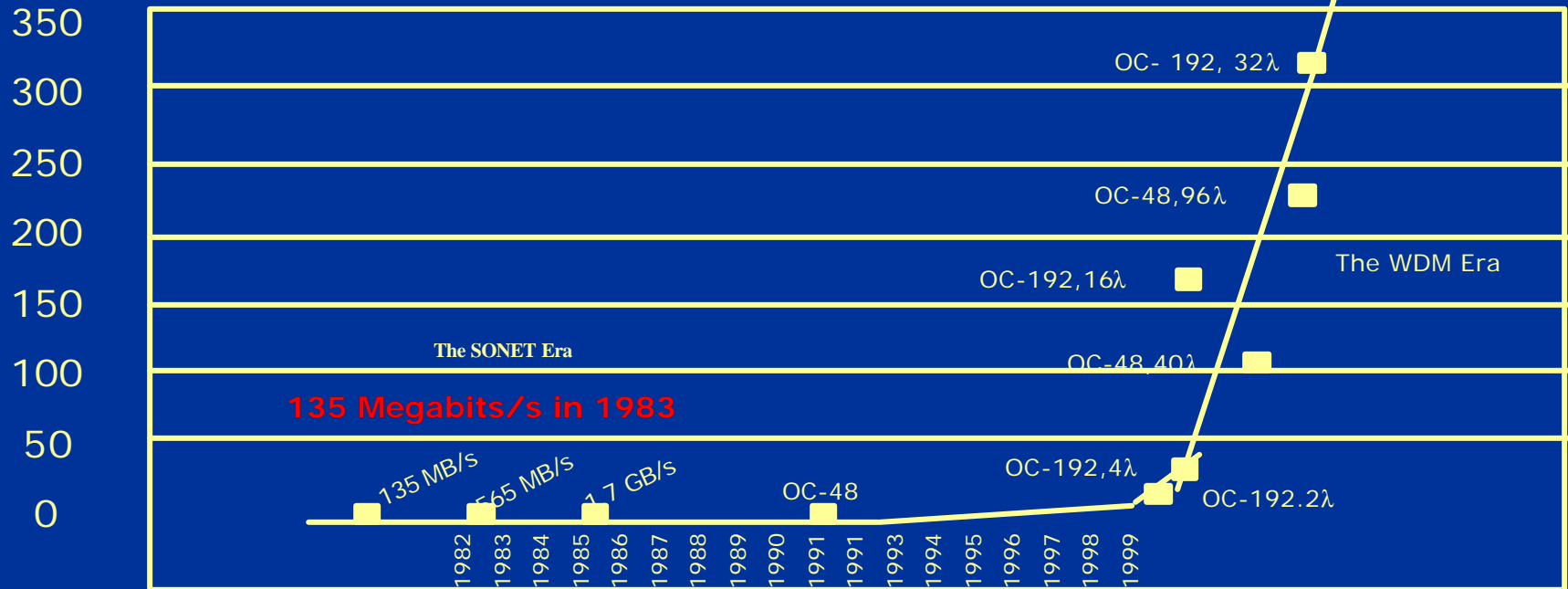
1.6 Terabits/s in 2002

350

300

250

200

150

The SONET Era

100

135 Megabits/s in 1983

50

0

135 MB/s   565 MB/s   1.7 GB/s

OC-48

OC-192,4λ

OC-192.2λ

OC-48,40λ

OC-192,16λ

The WDM Era

OC-48,96λ

OC- 192, 32λ

1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1991 1993 1994 1995 1996 1997 1998 1999
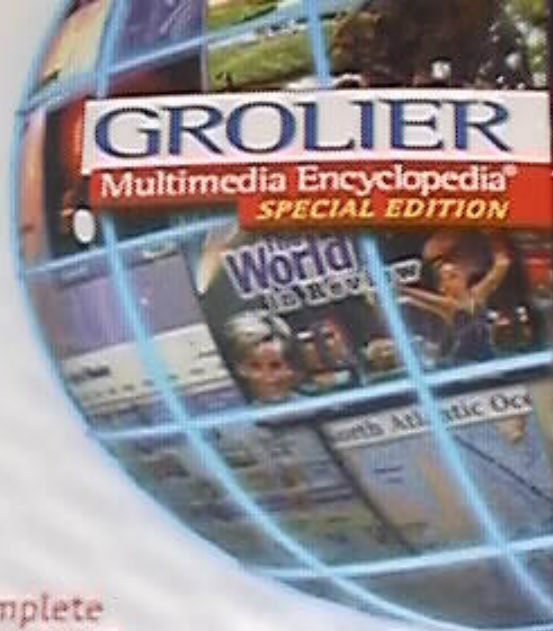
"Say Hello to the Freshmen"

Class of 2004, most ***born in 1982***

- The Kennedy tragedy was a plane crash, not an assassination.

- We have always been able to reproduce DNA in the laboratory.

- There have always been automated teller machines.

- "Spam" and "cookies" are not necessarily foods.

- Joysticks are operated with the left thumb.

Moore's Law and our students

Our student's lives

Our lives

Processor speeds from 1981 to 2015 (projected).

X-Chat [1.4.2]: sterling.openprojects.net / #blackbox

X-Chat   Windows   User Modes   Settings   Scripts & Plugins   User Menu   Help

oOOo ^^(_)^^ oOOo   T N S I P M L   K

4 ops, 32 total

```
<Glossifah| luqin: it's pure ansi C
  bkenoah| you do?  that's amazing!
<Glossifah| ?
    luqin| yeah
<Glossifah| Why zat?
  bkenoah| I consider that hard
      —->  steele (steele@p3E9B9B2B.dip.t-dialin.net) has joined #b
            lackbox
<Glossifah| bkenoah: OpenGL is easy, as long as you understand and c
            an envision things in cartesian coordinate space
            transformations by hand are interesting
    luqin| the difficult things come when you have to write algorit
<Glossifah| hms for calcualating vertex normals for correct specular
            lighting
  bkenoah| any high level math?
<Glossifah| it's linear algebra
    luqin| yeah we did that
    luqin| the old cliche'd mirrored spheres and checkerboard walls
```
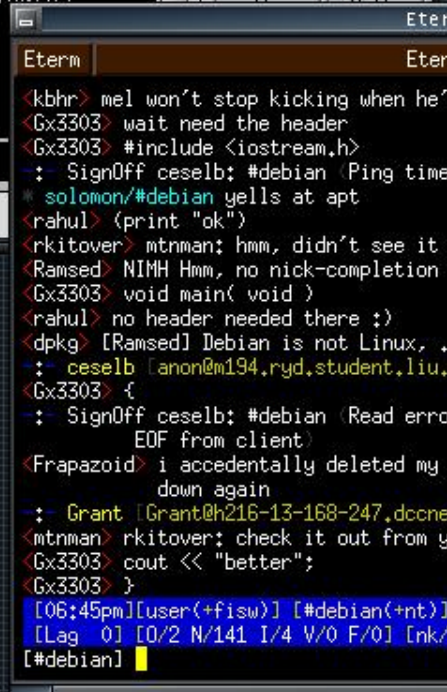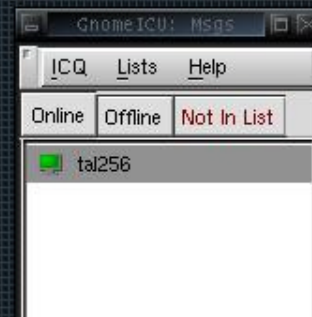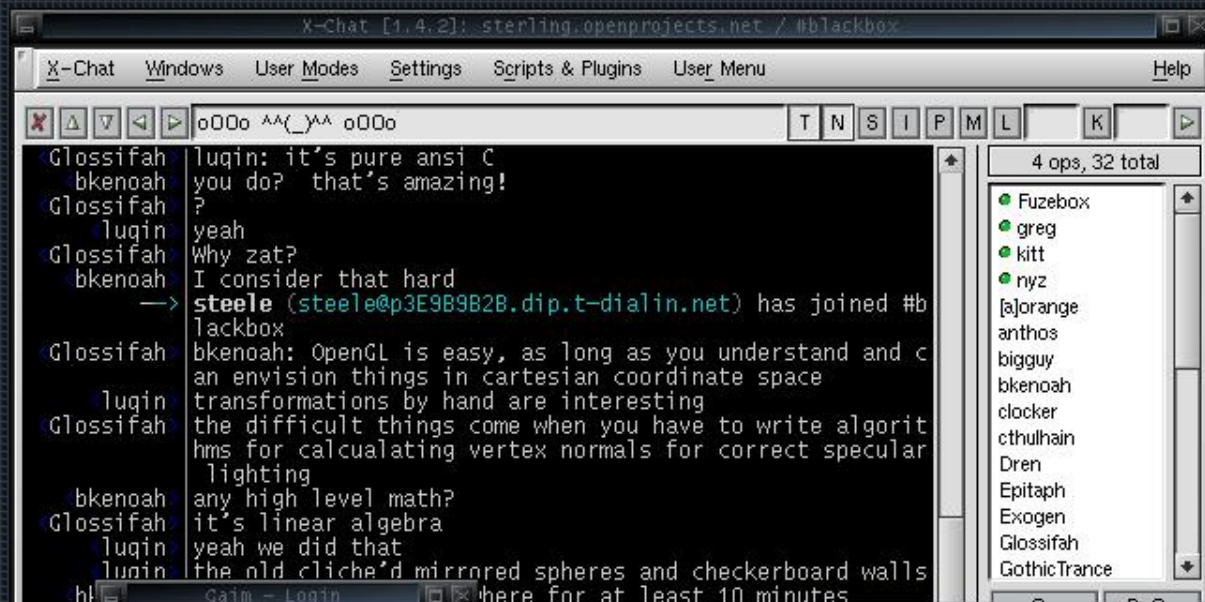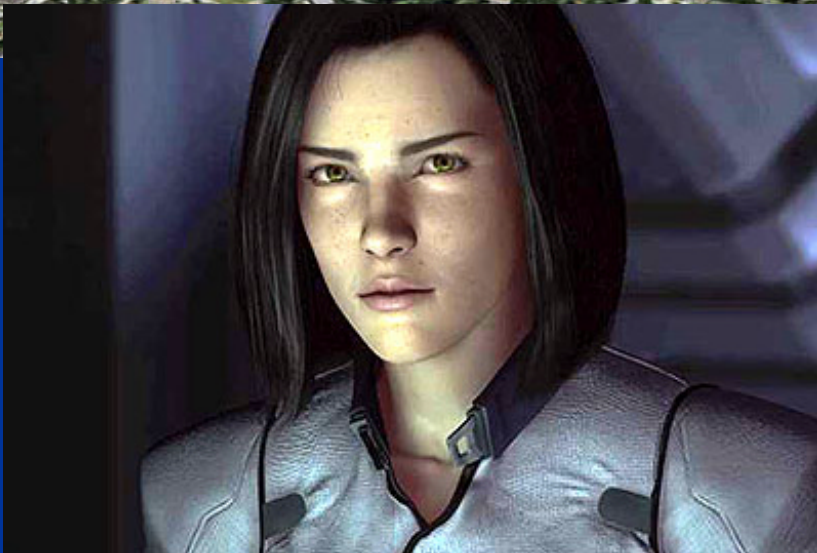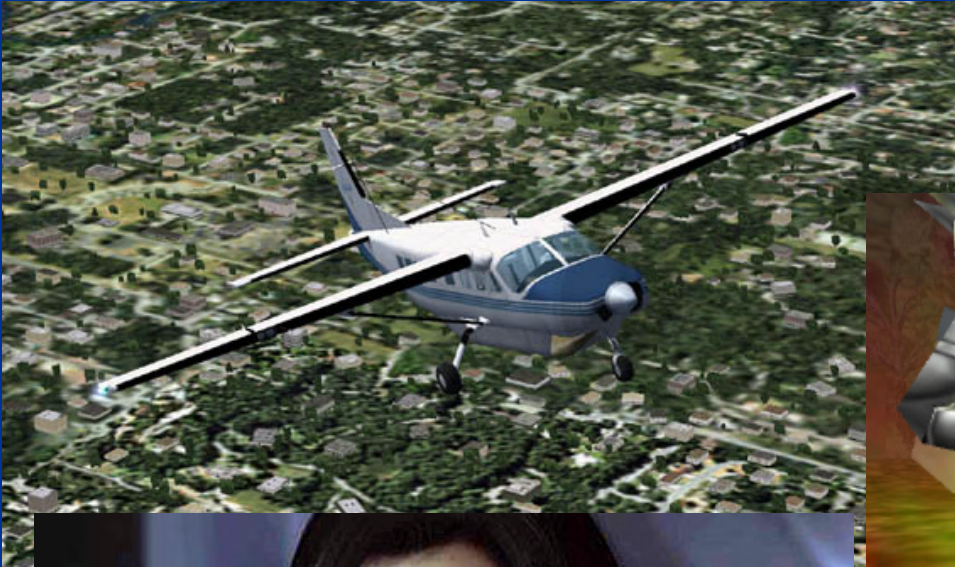
● Fuzebox
● greg
● kitt
● nyz
[a]orange
anthos
bigguy
bkenoah
clocker
cthulhain
Dren
Epitaph
Exogen
Glossifah
GothicTrance

GnomeICU: Msgs

ICQ   Lists   Help

Online   Offline   Not In List

🖳 tal256

---

gAIM — Login

gAIM

Screen Name: <unknown>
Password:

☑ Remember Password

[Register] [Cancel] [Signon]

[Options]   [Plugins]

POKÉMON
GENGARS   **CHAT ROOM**

Eterm

```
<kbhr> mel won't stop kicking when he's
<Gx3303> wait need the header
<Gx3303> #include <iostream.h>
 -: SignOff ceselb: #debian (Ping timed
* solomon/#debian yells at apt
<rahul> (print "ok")
<rkitover> mtnman: hmm, didn't see it
<Ramsed> NIMH Hmm, no nick-completion
<Gx3303> void main( void )
<rahul> no header needed there :)
<dpkg> [Ramsed] Debian is not Linux, .
 -: ceselb [anon@m194.ryd.student.liu.
<Gx3303> {
 -: SignOff ceselb: #debian (Read error
             EOF from client)
<Frapazoid> i accedentally deleted my
             down again
 -: Grant [Grant@h216-13-168-247.dccne
<mtnman> rkitover: check it out from y
<Gx3303> cout << "better";
<Gx3303> }
[06:45pm][user(+fisw)] [#debian(+nt)]
[Lag  0] [0/2 N/141 I/4 V/0 F/0] [nk/
[#debian]
```

Eterm-0.8.10

---

xterm

```
% zurite kuerner -w so are you still stuck doing the same thing at work today?
zurite: No match.
% Personal Message at 10:49:24 on Thu Jul 19
how's work going?
        Karolina M Werner <kwerner> on unix4
% zurite kuerner -w it is going pretty well...could be better or could be worse
kwerner: Message sent
% zurite kuerner -w you?
zurite: No match.
% zurite kuerner -w how about you
kwerner: Message sent
%       Personal Message at 10:50:41 on Thu Jul 19
i'm getting sick of this job, good thing only 3 more weeks....
        Karolina M Werner <kwerner> on unix4
zurite kuerner -w yeah this whole work thing does get old...
kwerner: Message sent
% zurite       Personal Message at 10:51:51 on Thu Jul 19
yeah, i think i'll go straight from college to retirement and skip that whole car
eer thing.
        Karolina M Werner <kwerner>
> on unix4
% zurite kuerner -w sounds like a good plan to me...if you figure out how let me
know too
kwerner: Message sent
% Personal Message at 10:52:44 on Thu Jul 19
well i have two options:
        Karolina M Werner <kwerner> on unix4
Personal Message at 10:53:04 on Thu Jul 19
one word: lottery
or two words: rich husband
        Karolina M Werner <kwerner> on unix4
        schmidt2 logged in to unix13
on unix13.andrew.cmu.edu:20.0 at Thu Jul 19 10:54:48 2001
```

Workspace 2

A $9B industry (and growing)

Massive multiplayer environments

Sims Online
Projected 3M
subscribers

Lineage
2M subscribers
100K simultaneous users
(in Korea)

Where is Military R&D?

An Academic's View

The Innovator's Dilemma

Describes the failure of companies to stay atop their industries when confronted with market and technological change

One common theme

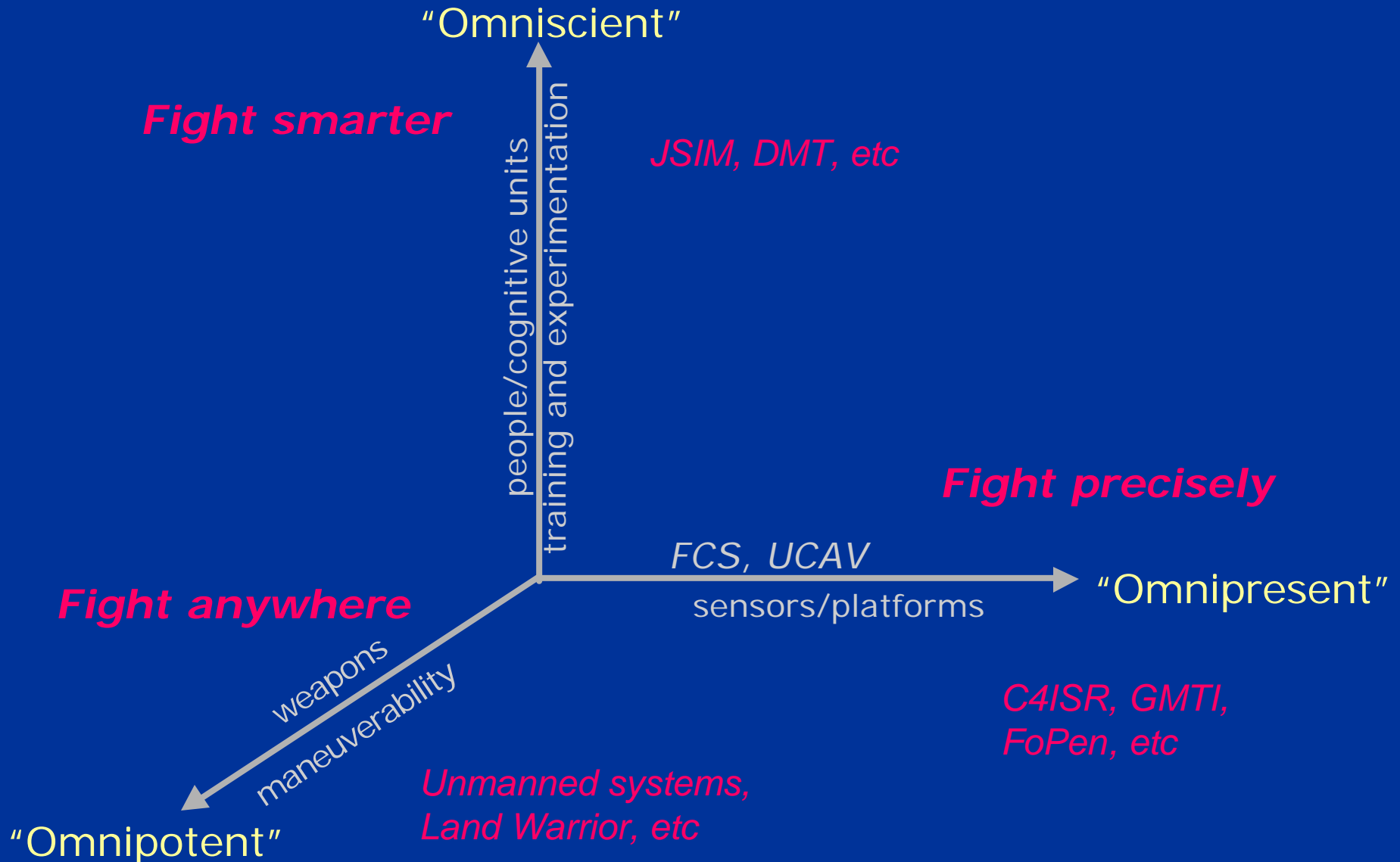- All happened when companies were ***widely regarded as among best*** in the world

*Clayton M. Christensen, Harvard Business School Press, 1997.

DoD's S&T challenge

Do what is right for near-term health,

while simultaneously

focusing adequate resources on "disruptive" technologies

A framework...

"Omniscient"

Fight smarter

JSIM, DMT, etc

people/cognitive units
training and experimentation

Fight precisely

FCS, UCAV
sensors/platforms

Fight anywhere

weapons
maneuverability

"Omnipresent"

*C4ISR, GMTI,
FoPen, etc*

"Omnipotent"

*Unmanned systems,
Land Warrior, etc*

Biological warfare defense

The DSB/TRAC Task Force concluded that:

- *"The present U.S. defensive effort ... will not effectively counter the current threat."*

- *"This effort is hampered by an absence of a vision of what is required and lacks leadership and coherent organizations."*

Three DoD studies (1999 DSB SS, 2000 DSB, 2001 DSB/TRAC) make recommendations.

Bio-Warfare Capabilities Countries

16

1990   2000
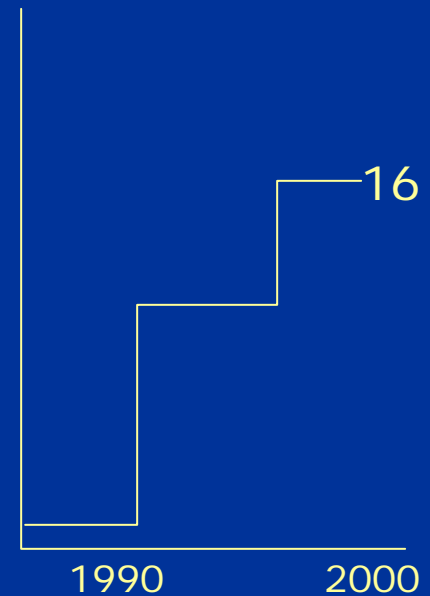
Sources: Roberts, "Biological and Toxin Weapons," Institute for Defense Analyses, at Biological and Toxin Weapons Convention, Vienna, Austria, 1998.
Cole, Spector of Biological Weapons," Scientific American, 1996

Is there a strategic niche for DoD?

Industry is profit-driven

- GlaxoSmithKline has >$4B R&D budget, but not on BW agents

NIH is research-driven, not a system integrator

HHS focused on conventional (rapid) response

How to capture bio-talent?

The USS Yorktown

"After a crew member mistakenly entered a zero into the data field of an application, the computer system proceeded to divide another quantity by that zero. *The operation caused a buffer overflow, in which data leaked from a temporary storage space in memory, and the error eventually brought down the ship's propulsion system.* The result: *the Yorktown was dead in the water for more than two hours*."

"Better, Faster, Cheaper"

A long-term strategy for IT research in DoD?

DoD should clearly define and strengthen its focus on basic, long-term, technology for dependable information systems.

Need to dispel the notion that "software is a solved problem."

DARPA IEO and IAO are good new directions.

Layered ISR

A few high altitude assets find and cue to possible targets

Some mid-range air assets find, identify or cue, relay and designate

Numerous small surface sensors identify and communicate
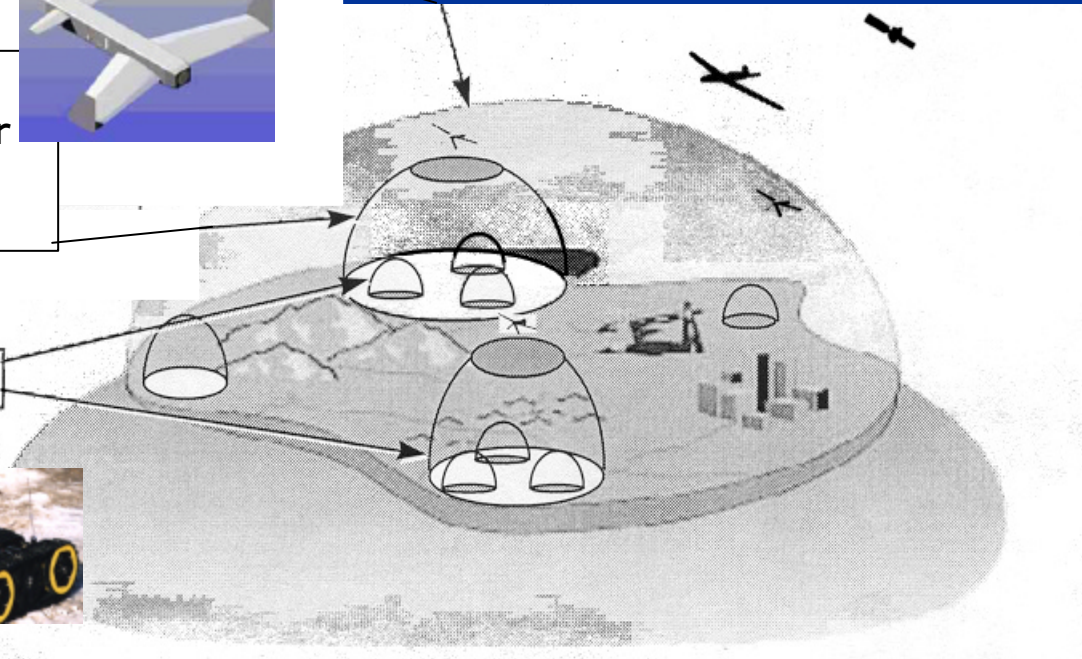
A "captain's war"

"Afghanistan is a captain's war… Spotters on the ground decided to bypass the heirarchical loop… Instead they gave target coordinates directly to the planes overhead, reducing response time to 19 minutes or less. That's half the time it takes to go through the command loop and less than it can take in military exercises, where the operation is scripted."

Stan Crock, Business Week Online, Dec.17, 2001

C4ISR is probably a technological *and* a cultural change

A training revolution?

The 1999 DSB Study on Training Superiority and Training Surprise found:

- Some forms of training can deliver order-of-magnitude improvements

- Warfare in 2010/2020 will require *more* training, not less

- *A training revolution is possible*

- *Adversaries could use a new training revolution against us*

The average 18-year old has 1500 hrs in simulated environment

Over 2% of the Korean population subscribes to the MMP game *Lineage*.

ON MONTHLY

SNEAK PREVIEW! A FIRST LOOK AT THE HARRY POTTER GAME

YOUR WHERE-TO-GO, HOW-TO-DO-IT GUIDE TO BEING CONNECTED

DIGITAL-PHOTOGRAPHY PRIMER: PART ONE
MAKE YOUR OWN MUTUAL FUNDS
MOTHER AND CHILD REUNION—ONLINE
THE SEARCH FOR HARD-TO-FIND FOOD

JUNE 2001

SUPPLEMENT TO TIME MAGAZINE

A SPECIAL REPORT
ON AMERICA'S
OBSESSION WITH
ELECTRONIC GAMES

THIS KID CAN
KICK YOUR BUTT
(IN POKÉMON)

Still, we bet you're like the majority of American adults: a secret gamer
▶ Our favorite games
▶ Why they're not just child's play
▶ Tips for getting started

Ian Garvey, 14,
Pokémon 2000 USA
champion

Continuous competitive pressure spurs innovation

Does MMP have a role in training, doctrine, and experimentation?

Continuous competitive pressure spurs innovation

WWII Online after-action reports

- Choosing & training leaders to think differently
- Game "gods" anoint leaders
- Alternatively, leaders can earn position
- Ability to devise and execute a mission is the reward…
- Analysis of outcomes is key

Concluding Remarks

Enhancing the vitality of DoD S&T

Heightened awareness of the importance of national defense presents DoD with an opportunity to capture top S&T talent.

Is it time for a small set of "going to the moon" projects?

Who is the "CTO"?

Acknowledgments

Defense Science Board
- 2001 S&T Study: Anita Jones, Larry Lynn, Regina Dugan

Army Science Board

CMU, especially
- Tom Mitchell, Randy Pausch, Bill Scherlis
- Ken Gabriel (CMU Security Technology Office)